Turbulence Intensity Study at Inlet of 80- by 120-Foot Wind Tunnel Caused by Upwind Blockage

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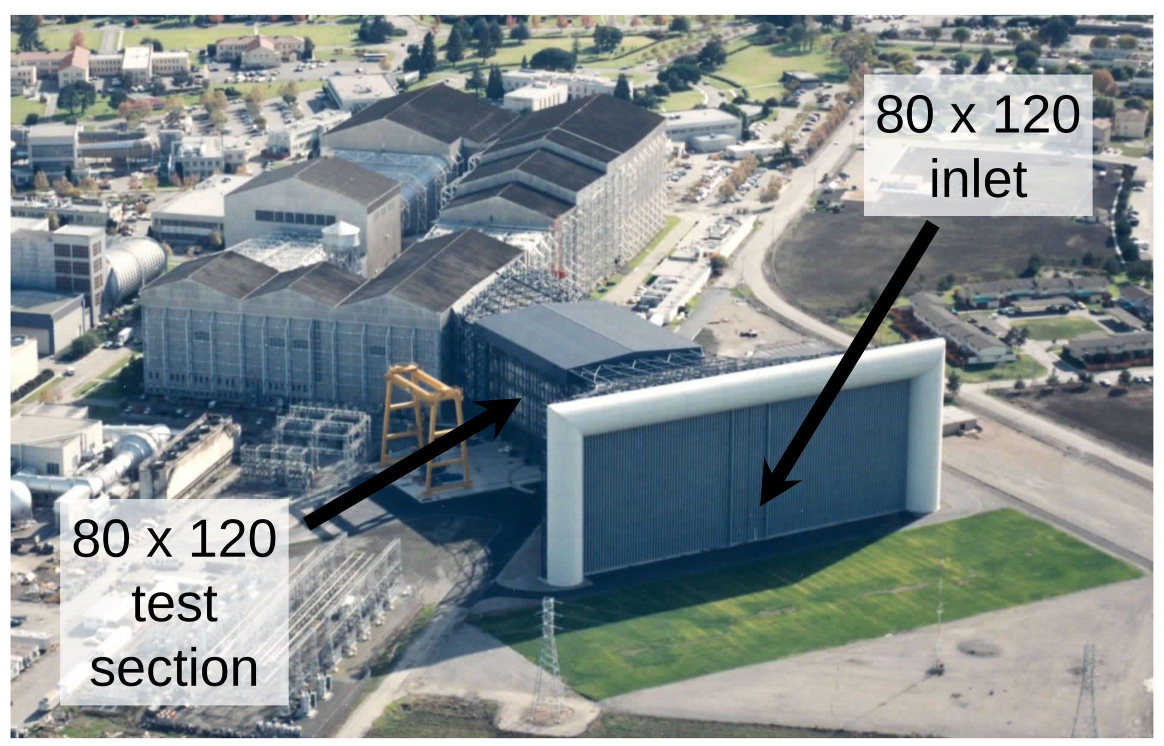
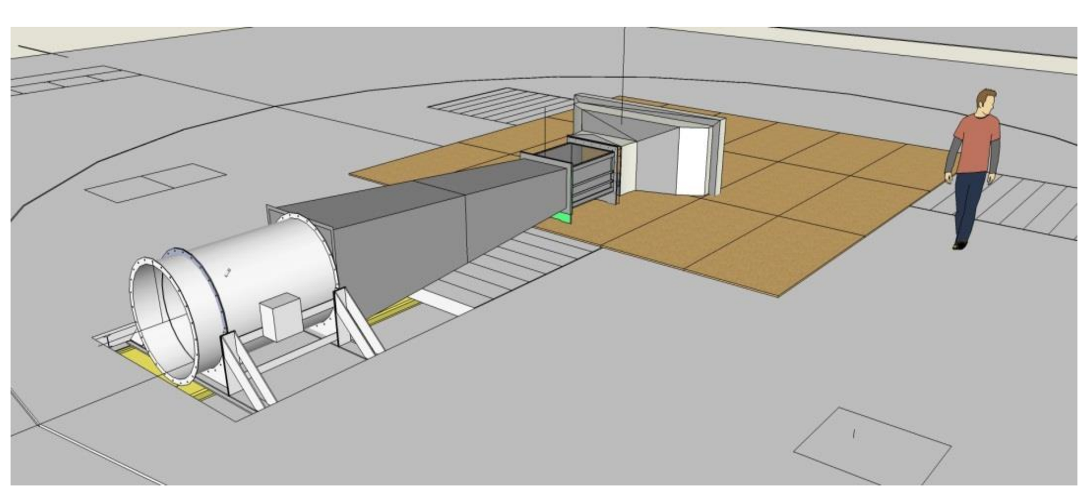
Introduction

The National Full-Scale Aerodynamics Complex (NFAC) 80- by 120-Foot Wind Tunnel (80 x 120) at NASA Ames Research Center is the largest in the world with an inlet bigger than a football field. Because ambient air is drawn into the test section, the effects of upwind blockage are important. With a new Google complex under construction approximately 1400 feet upwind of the inlet, NASA wanted to better understand what affect these and future structures might have on the wind tunnel flow quality.

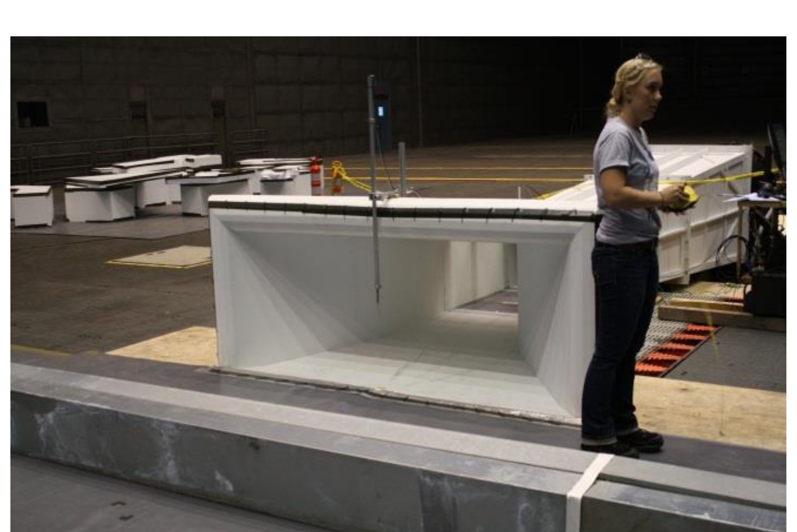


Experimental Setup

- 1/50th-scale model 80 x 120 (inlet and test section) placed on the full-scale NFAC turntable for testing.
- Rear blower pulls air through the inlet at speeds comparable to the full-scale facility (100 knots maximum in the test section).



- Six U-beams were arranged to form a 1ft x 1ft x 36 ft blockage in front of the 1/50th-scale inlet.
- Cobra probe is shown mounted on the inlet centerline.

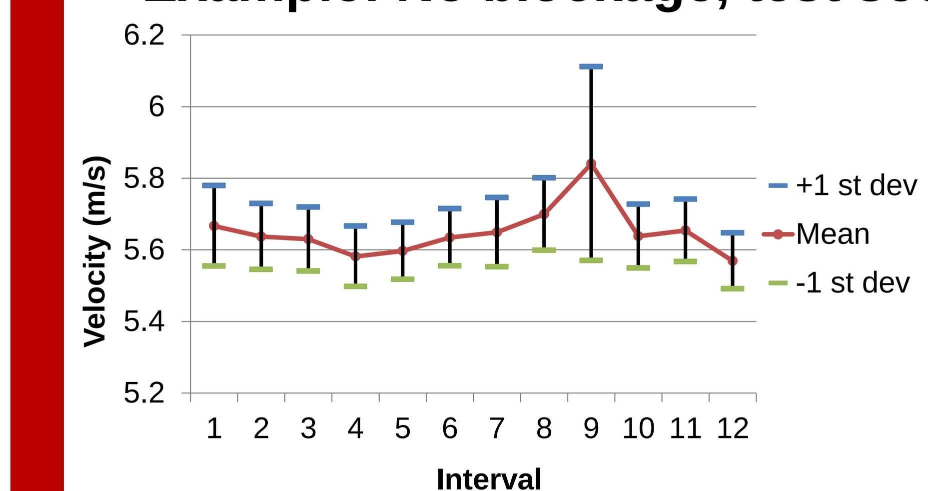


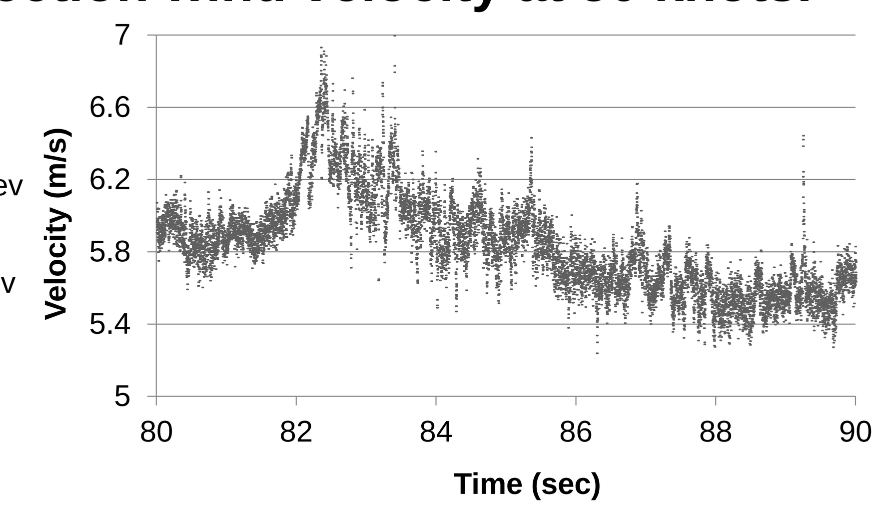
Method

- Inlet centerline velocity measurements were acquired with the blockage at varying distances (x_b) ahead of the inlet from 1 to 20 ft.
- Test with no blockage was used as a control data point.
- Two minutes of data collection for each data point.
- Used two different blower speeds to represent full and half speed velocity in the test section, 100 and 50 knots respectively.
- Each data point was divided into ten-second intervals and the mean velocity and standard deviation were calculated for each.

Results

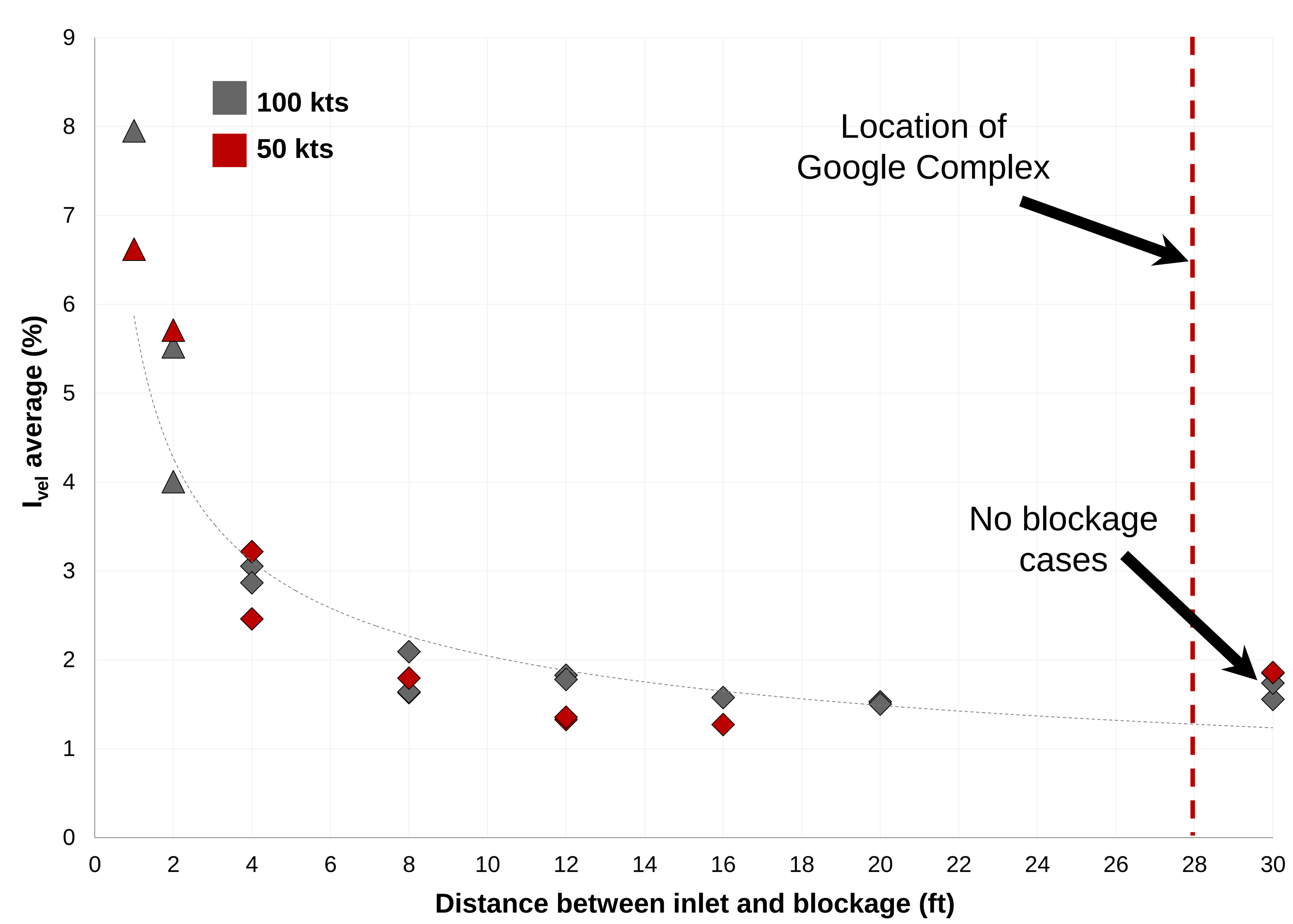
Example: No blockage, test section wind velocity at 50 knots.





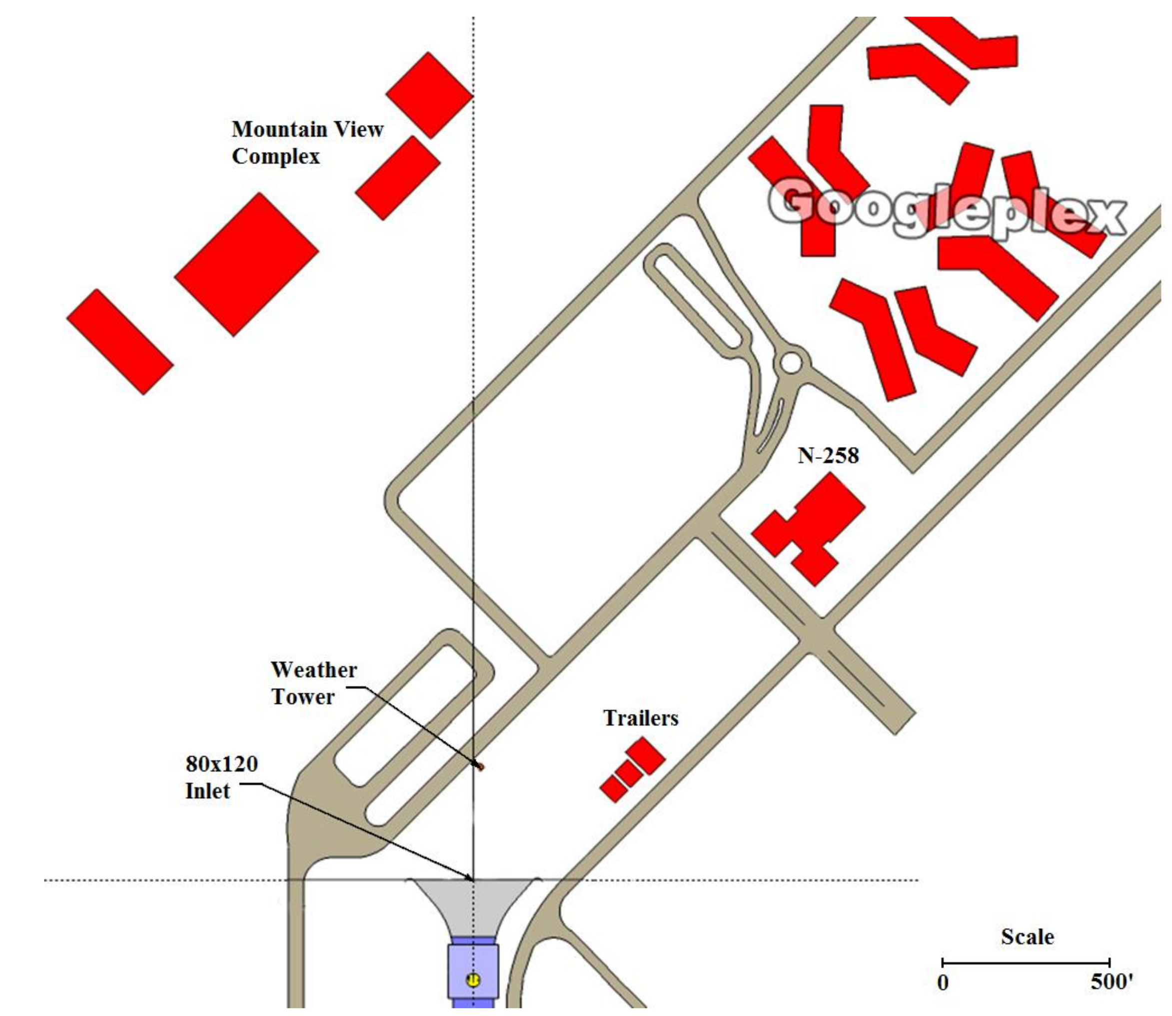
- Left plot shows increase in standard deviation/mean at Interval 9.
- Right plot shows that a drift in velocity caused the unusually high value of standard deviation and mean in Interval 9.
- Example displays how a moving mean can contribute to a false indication of high turbulence (source of drift is unknown).

Measurements at each x_b of the inlet centerline relative turbulence intensity, defined as the rms standard deviation in the velocity divided by the mean velocity, are shown below:



Conclusions

The generic 2-D blockage is shown to produce no meaningful increase in inlet centerline turbulence for blockage more than 20ft (1000ft at full-scale) ahead of the inlet, for the case of zero atmospheric winds. This implies no measureable increase in test section turbulence for the same conditions.



Since the Google complex will be located approximately 1400 feet ahead of the inlet, NASA is confident that the construction will have little effect on the flow quality in the 80 x 120 wind tunnel for quiescent atmospheric conditions.

Further Investigation

Representative 1/50th-scale vertical inlet vanes, horizontal splitter plates, and leading-edge and trailing-edge screens have been designed and are awaiting construction.

Test section turbulence measurements will be made for the existing upwind building configuration, the planned Google construction, and for the generic 2-D blockage as soon as the inlet treatment becomes available.

Acknowledgments

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References

1. Oaks, B., "Aerodynamic Characteristics of the 80- by 120-Foot Wind Tunnel," NASA Ames Research Center, 2013.
2. Schmidt, G., Rossow, V., Van Aken, J., & Parrish, C., "One-Fiftieth Scale Model Studies of 40- by 80-Foot and 80- by 120-Foot Wind Tunnel Complex at NASA Ames Research Center," NASA TM 89405, 1987.